MASTER OF SCIENCE
IN
COMPUTER SCIENCE

SYSTEM EVALUATION OF HARDWARE AND SOFTWARE FOR A STREAMING MULTIMEDIA SERVER USING THE MULTICASTING PROTOCOL

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The next step in the evolution of services provided on an intranet or the internet will be distributed or distance learning with collaboration among peers. Currently, this is done on a one-to-one basis. To expand to a one-to-many collaboration environment, there needs to be a server distributing the multimedia content without creating additional network traffic even though many users are accessing or viewing the multimedia content. Multicasting allows many users to view multimedia content without creating additional network traffic. There is a server providing multimedia content to a multicast address so users may access it. This thesis defines metrics and conducts a comparison of different servers capable of distributing multimedia content using the multicasting protocol.

KEYWORDS: Multicast, Server, Network, Multimedia, Streaming

SECURITY AND EFFICIENCY CONCERNS WITH DISTRIBUTED COLLABORATIVE NETWORKING ENVIRONMENTS

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The progression of technology is continuous and the technology that drives interpersonal communication is not the exception. Recent technology advancements in the areas of multicast, firewalls, encryption techniques, and bandwidth availability have made the next level of interpersonal communication possible.

This thesis answers why collaborative environments are important in today's online productivity. In doing so, it gives the reader a comprehensive background in distributed collaborative environments, answers how collaborative environments are employed in the Department of Defense and industry, details the effects network security has on multicast protocols, and compares collaborative solutions with a focus on security. The thesis ends by providing a recommendation for collaborative solutions to be utilized by NPS/DoD type networks. Efficient multicast collaboration in the framework of security was a secondary focus of this research. As such, it takes security and firewall concerns into consideration while comparing and contrasting both multicast-based and non-multicast-based collaborative solutions.

KEYWORDS: Security and Efficiency Concerns with Distributed Collaborative Networking Environments, Collaborative Environments in the Department of Defense and Industry, Effects of Network Security on Multicasting, Collaborative Solutions, Collaboration, Multicast, Firewall

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IMPACT OF THE TELECOMMUNICATIONS ACT OF 1996 AND SPECTRUM ALLOCATION ON CELLULAR TELEPHONE TECHNOLOGY
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From 1983, when the first cellular network was established, to 1992, the wireless industry grew by ten million customers. From 1993 to 2000, the wireless industry grew by 90 million customers. Today, there are more than 149 million U.S. wireless subscribers. The phenomenal growth of the wireless industry can be traced to several factors. These factors are improvements in cellular technology, expansion of that technology, and the allocation of spectrum by the federal government.

This thesis analyzes the correlation between the Telecommunications Act of 1996 (the Act) and the rapid expansion of cellular technology that occurred after the Act became law. It also analyzes the impact of spectrum management and allocation on the evolution of cellular technology. To demonstrate how cellular technology has evolved over time, the history, standards, and generations of cellular technology were reviewed. Research findings are shown that validate the Act's impact on the expansion of cellular technology. Finally, the impact of spectrum management and allocation on the evolution of cellular technology in the United States, specifically in terms of implementation of third generation (3G) technology, is shown by analyzing the policies of the government organizations responsible for managing the frequency spectrum.

KEYWORDS: Telecommunications Act of 1996, Cellular Technology, Spectrum Allocation, First Generation, 1G, Second Generation, 2G, Third Generation, 3G

3D BATTLESPACE VISUALIZATION USING OPERATIONAL PLANNING DATA
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In modern combat operations today, the display of operational data is still tied to stove-piped and proprietary systems and software. Additionally, combat systems are still using 2D displays of the battlefield in order to reflect a picture of the battlefield to the warfighter. Stepping away from stove-piped and proprietary systems and reflecting a 3D picture of the battlefield is the direction that this thesis research explores.

Research is conducted to explore technologies needed to provide operational forces with web-based 3D visualizations of operational data. Technologies used in this research are Extensible Mark-up Language (XML), Extensible Stylesheet Language for Transformation (XSLT), JAVA, Extensible 3D Graphics (X3D), and Virtual Reality Modeling Language (VRML). A prototype application is developed that allows for the 3D display of operational data. The research demonstrates how operational data can be stored in a database and accessed through a web-based 3D representation of the area of operation. Data sets used in this prototype include Digital Terrain Elevation Data and operational planning data. Access to the data is provided through a web-based interface. The web-based view of the data provides both 2D and 3D views. This research shows that current open source technology can provide the warfighter with a web-based 3D view of the battlefield.

KEYWORDS: Virtual Environments, Extensible 3D Graphics, X3D, Extensible Markup Language, XML, Java, Scenario Generation, Combined Operational Picture, COP, Extensible Modeling and Simulation Framework, XMSF, SAVAGE, Database

COMPUTER SCIENCE

**MULTI-AGENT SIMULATIONS (MAS) FOR ASSESSING MASSIVE SENSOR COVERAGE
AND DEPLOYMENT**

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The thesis presents the design, development, and implementation of a multi-agent simulation that models coverage and deployment of mobile and non-mobile sensors performing collaborative target-detection missions. The focus is on sensor networks with enough sensors that humans cannot individually manage each sensor. Experiments investigate novel search, coverage, and deployment algorithms, and compare them to known methods. The experiments show algorithms productive for area coverage are not useful for detecting unauthorized traversals and vice versa. Obstacles, sensor mechanisms, mission parameters, and deployment schemes are analyzed for their effect on coverage quality. This work facilitates further research in sensor coverage and deployment strategies using sensor agents.

KEYWORDS: Sensor Network, Coverage, Deployment, Exposure, Java, Artificial Intelligence, Agent, Simulation

DYNAMIC CHANNEL ALLOCATION

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In this thesis, Dynamic Channel Allocation (DCA) offers the possibility of capturing unused channel capacity by allocating unused resources between competing network nodes. This can reduce or possibly eliminate channels sitting idle while information awaits transmission. This holds potential for increasing throughput on bandwidth constrained networks.

The purpose of this thesis is to examine the techniques used to allocate channels on demand and access such methods ability to maximize throughput. This thesis will also explore potential benefits to be gained by DCA through the use of computer simulation.

KEYWORDS: Dynamic Channel Allocation, Fixed Channel Allocation, Inverse Multiplexing

**AN OPEN ARCHITECTURE FOR DEFENSE VIRTUAL ENVIRONMENT TRAINING
SYSTEMS**

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This thesis develops a proposed software system that is usable by programmers to create virtual reality training environment applications for military (or other) use in which characters and character animation are necessary. Such applications are becoming more necessary to fill a gap in military training due to lack of personnel, time, money, and resources. Creation of virtual environment training applications allows military units to augment procedural training in preparation for live or physically simulated training. In the current environment of lesser training and more military requirements, such augmentation will only serve

to benefit unit capabilities. While such systems for developing virtual environment applications are commercially available, those systems are costly in both licensing and usage fees. One of the tenets of the system that this thesis develops is that this system will be free and partially open source, such that programmers can create low cost virtual environment applications for military training, and such that experienced programmers can modify or add to the system in order to improve or enhance its capabilities to meet their needs.

KEYWORDS: Character Animation, Motion Capture, MOUT, Close Quarter Battle, CQBSim, Training, Virtual Environment, Open Source, Scene Graph, Software Architecture

INTEROPERABILITY, DATA CONTROL, AND BATTLESPACE VISUALIZATION USING XML, XSLT AND X3D

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This work represents the realization of Network-Centric goals of interoperability, information management, systems integration, and cohesive battlespace visualization using networked computer technology. The application of structured data methodologies using the Extensible Markup Language (XML) allows organizations and systems to exchange and process battlespace information cooperatively. The practical application of this technology is demonstrated.

Governance of information systems using structured data and the rejection of proprietary, application specific solutions is a leadership responsibility that is defined as Data Control. XML is presented as a leadership control measure that can be used to achieve Network-Centricity on the battlefield.

The fundamental principles of XML application development are presented in the context of warfighting. Exemplars address a cross-section of battlespace applications. The visualization of the physical battlefield is demonstrated with network delivered 3D terrain views. Geodesy and position reporting is addressed using an XML defined data structure to enforce interoperability. An XML expression of the Battlespace Generic Hub is applied to joint and multilateral interoperability and information exchange. An approach to the effective employment of multiple different, but cooperative, autonomous systems in the battlespace uses XML to define parameters that determine artificial intelligence multi-agent behavior and environmental factors.

This thesis combines a critical analysis of the priorities of Network-Centricity and interoperability with practical and functional exemplars that demonstrate the efficacy of extensible architectures. The pragmatic approach is directed at the warfighter, and leadership challenges are identified.

KEYWORDS: Extensible Markup Language, XML, Extensible 3D Graphics, X3D, Extensible Stylesheet Language for Transformation, XSLT, XML Schema, Interoperability, Battlespace Visualization, Command and Control, Data Control, Digital Terrain Elevation Data, DTED, Geodesy, Position Reporting, Unmanned Aerial Vehicle, UAV, Multi-Agent Systems, Battlespace Generic Hub, Land Command and Control Information Exchange Data Model, LC2IEDM, ATCCIS, Network-Centric Warfare, Java, Extensible Modeling and Simulation Framework, XMSF, MOVES, SAVAGE

A REALISTIC MODEL OF NETWORK SURVIVABILITY

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This thesis focuses on evaluating network survivability and Quality of Service (QoS) in a network. There have been studies on developing network survivability metrics: however, the implementation of these

survivability measures is usually based on unrealistic assumptions. This thesis has some experiment results based on identifying all min-cuts of a network and computing survivability of the nodes based on these criteria.

The main contribution of the thesis is a novel approach to handling correlated or dependent component failures. In a complex network, it is not trivial to compute the probability of failures of the nodes even if the component failures are independent. With this new approach, network administrators could predict the optimal nodes in a network under more realistic conditions. Java-based simulation programs are developed to evaluate the approach. This project is motivated by network security problems in which a decision maker has to select nodes to host critical information servers when there is an attack to the network. The solution will give the decision makers criteria that would help them to make better decisions.

KEYWORDS: Network Survivability, Network Attacks, Max Flow, Min-cut, Probabilistic Networks, Modeling Dependent Nodes, Graph Algorithms, Bayesian

AUTO-CONFIGURATION OF CISCO ROUTERS WITH APPLICATION SOFTWARE
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The context of this research is to facilitate the control of routers with the Server and Agent based Active Network Management (SAAM), to optimize allocation of network resources, and to satisfy user Quality of Service (QoS) requirements. The SAAM network determines the Quality of Service parameters based on current network conditions and user requirements. These parameters are dynamic, so they must be uploaded into the Cisco routers to take effect. The focus is on determining the most efficient way of communicating between the Cisco routers and the SAAM system. This is accomplished by several key components of the proxy-based solution as the first step for integrating with a legacy network.

This thesis develops methods and application software to automatically update the configurations of Cisco routers based on the current network condition. These methods are required by any solution that resolves to upgrade the existing legacy network to provide QoS without expensive equipment replacement. As a result, users are provided with a network they can expect to function properly.

KEYWORDS: Cisco, IOS, Console, Ethernet, Telnet, SSH, QoS, Perl, Socket, HyperACCESS, API, HAPI, Visual Basic, C++

AN EVALUATION OF THE NETWORK EFFICIENCY REQUIRED IN ORDER TO SUPPORT MULTICAST AND SYNCHRONOUS DISTRIBUTED LEARNING NETWORK TRAFFIC
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The United States military has had, and will continue to have, a legacy of comparatively short tours and long deployments in locations where the availability of all forms of education and training may be limited. This not only limits the potential of military members but can have a detrimental effect on morale and retention. Distributed Learning is one way to combat this ever increasing dilemma.

With the proliferation of computer technology and Internet access throughout the Department of Defense (DoD), Distributed Learning can put education and training at the finger tips of most military members. It can even bring education to the field, limited only by the networks, data delivery methods, and bandwidth provided military units.

This thesis examines the network requirements needed to provide a good quality of service (QoS) to sailors and soldiers, and provides guidelines for implementing Distributed Learning over multicast on DoD networks. Multicast is a very efficient method of delivering data to multiple recipients, and is the

underlying technology which can allow interactive Distributed Learning. It is therefore the primary focus of this thesis.

KEYWORDS: Multicast, Multicasting, Distributed Learning, Network, Protocol, PIM, DVMRP, IGMP, SAP/SDP, IGMP Snooping, Dense Mode, Sparse Mode

SECURE GROUND-BASED REMOTE RECORDING AND ARCHIVING OF AIRCRAFT "BLACK BOX" DATA
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Aircraft accident investigation centers upon the analysis of all available information about the accident flight in the period leading up to the final catastrophe. Key among the sources of information is data captured and recorded in the flight data recorder and cockpit voice recorder, which are often referred to as the aircraft "black boxes." For some accidents, this flight data may be lost entirely or partially damaged and largely unusable. The aircraft flight data recorders are the only place where flight data is recorded. This single recording point is a vulnerability to the availability of flight data that can be addressed by creating another place where the data is stored. This thesis examines the feasibility of, and discusses the technical framework necessary for, a system that transmits flight data from an aircraft to a ground recording station. The focus will be upon the requirements for security and assurance of the information flow, so that the confidentiality, integrity, availability, and authenticity of the data are ensured.

KEYWORDS: Black Box, Aircraft Flight Data

MANPOWER REQUIREMENTS DATABASE FOR THE GREEK NAVY
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The Greek Navy is trying to create a Web-enabled Database system, which will enhance and facilitate the process of assigning duties (jobs) to its officers.

This study provides a prototype for implementing the job-to-officers assignment process by creating a manpower Database accessed via the Internet. This prototype is based on the 3-tier architecture, having both the Web and Database design and implementation. Behind the scenes is a multi-criteria decision algorithm that takes the officers' credentials and the officers' and commands' preferences into account and then determines the best distribution of the officers to the available jobs.

This thesis and the supporting research will strive to develop the requirements and a working prototype web site for the detailer, and reduce both manpower and time required to complete the assignment process conducted by the Greek Navy's Department of Personnel.

KEYWORDS: Web-enabled Database, Relational Database, Manpower Systems, Three-tier Application, Multi-criteria Decision Problem, Algorithm, Greek Navy, Officer, Command, Credentials, Qualifications, Officer's Preference, Command's Preference

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AN OPEN-SOURCE AND JAVA-TECHNOLOGIES APPROACH TO WEB APPLICATIONS
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Web applications have become a critical component of the global information infrastructure. In government organizations, proprietary software is currently being replaced by open-source. This thesis explores using open-source and Java technologies to implement Web applications. A prototype of the framework was implemented for a military information site. Implementation was straightforward and performance of the prototype was excellent, demonstrating advantages in terms of reliability, portability, maintainability, and economy.

KEYWORDS: Web Application, Open-source Software, Java Servlets, Java Server Pages, JSPs, Linux, Web Server, Structured Query Language, SQL, Java Database Connectivity, JDBC

THE ARTILLERY FIRE DIRECTION CENTER SIMULATION
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In recent years, declining budgets, limitations on artillery ammunition, and decreases in training areas have reduced the opportunity to conduct live fire artillery training. For these reasons, simulation systems are available for providing an almost realistic training platform for the forward observer. One of them is "The Forward Observer Personal Computer Simulator (FOPCSIM)," which is the thesis work of two students, David Brannon and Michael Villandre. FOPCSIM is a useful tool for the training of the forward observer without major requirements. However, it is a stand-alone system and many of the actual procedures of the observed fire are provided by the system. This thesis presents another system, which simulates the Fire Direction Center procedures during a firing mission. The two systems have a network communication for exchanging messages, similar to the real communication messages between the forward observer and the FDC. Now, the training of the forward observer is more realistic because this person must take into account the existence of the FDC, must wait for responses for each message sent out, and must deal with problems such as communication errors, time delays in sending and receiving messages, and modifications in the call for fire from the FDC. The new system will provide feedback by keeping a history of each mission and giving the observer the capability to review the process of each mission and make useful conclusions about performance.

KEYWORDS: Field Artillery, Fire Direction Center, Forward Observer, Call for Fire, FDC, FOPCSIM, Training, Virtual Environment, Fire Support, Simulation

ANALYSIS OF VOICE QUALITY PROBLEMS OF VOICE OVER INTERNET PROTOCOL (VOIP)
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After its introduction in mid 1990s, Voice over Internet Protocol (VoIP), or IP telephony, has drawn much attention. The prospect of cost savings on long distance and international toll calls, the global presence of Internet Protocol (IP), and the trend to converge data networks with voice networks have made VoIP one of

the fastest growing telecom sectors. Additionally, the emergence of 3rd Generation (3G) cellular technology which offers high bandwidth will result in the convergence of the Internet and the cellular networks, which will further stimulate the growth of VoIP. However, VoIP faces many problems, mainly because of the nature of IP networks which were built to transport non-real-time data, unlike voice.

This thesis analyzes factors affecting the voice quality of VoIP. These factors are delay, jitter, packet loss, link errors, echo, and Voice Activity Detection (VAD). Further, implementation suggestions to lessen the effects of these factors are presented and finally, these suggestions are analyzed.

KEYWORDS: Voice Over Internet Protocol, VoIP, IP Telephony, Internet Telephony, H.323, Voice Quality

FULL-DUPLEX UNDERWATER NETWORKING
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This thesis focuses on developing a full-duplex underwater acoustic network and in developing a new protocol utilizing Demand Assigned Multiple Access (DAMA) and frequency division multiple access code (FDMA). This new protocol will be utilized to expand networking capabilities in an underwater environment. Benefits of advancements in this area include fiscal savings and optimization of bandwidth usage creating an increased rate of data transfer.

The research conducted in establishing a full-duplex UAN using FDMA will put the Naval Postgraduate School at the forefront of UAN technology, and make a significant contribution to understanding underwater networking, the benefits of full-duplex underwater networking, and full-duplex underwater networking using DAMA. These solutions will increase the efficiency and reliability of underwater data transfer and in turn, could be used for further research or as a stepping stone towards improved monitoring of oceanographic anomalies and littoral waters.

KEYWORDS: Half-duplex, Full-duplex, DAMA, FDMA, OMNeT++, Temperature, Salinity, Pressure, Noise Interference